



## ***Chapter 7 - Environmental Monitoring Programs (Agricultural, Wildlife, Soil and Direct Radiation)***

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### ***Chapter Highlights***

To help assess the impact of contaminants released to the environment by operations at the Idaho National Engineering and Environmental Laboratory (INEEL), agricultural products (milk, lettuce, wheat, potatoes, and sheep); wildlife (waterfowl, marmots, large mammals); and soil was sampled and analyzed for radionuclides. In addition, direct radiation was measured on and off the INEEL in 2003.

Some anthropogenic (human-made) radionuclides were detected in agricultural products, wildlife, and soil samples. For the most part, the results could not be directly linked to operations at the INEEL. With the exception of americium-241 in soils collected at the Radioactive Waste Management Complex (RWMC), concentrations of radionuclides detected in soil samples were consistent with fallout levels from atmospheric weapons testing. The maximum levels for these radionuclides were all well below regulatory health-based limits for protection of human health and the environment.

Americium-241 was detected above background levels in soil samples collected around the RWMC. However, the concentrations were consistent with those measured historically and are attributable to past RWMC operations and fallout.

Direct radiation measurements made at offsite, boundary, and onsite (except the RWMC) locations were consistent with background levels. The measured annual dose equivalent from external exposure was 119 mrem. Direct radiation measurements made at the RWMC were greater than background levels but consistent with those made historically at that location.



## 7. ENVIRONMENTAL MONITORING PROGRAMS - AGRICULTURAL PRODUCTS, WILDLIFE, SOIL, AND DIRECT RADIATION

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### 7.1 Organization of Monitoring Programs

This chapter provides a summary of the various environmental monitoring activities that relate to agricultural products, wildlife, soil, and direct radiation currently being conducted on and around the Idaho National Engineering and Environmental Laboratory (INEEL) (Table 7-1). These media are potential pathways for transport of INEEL contaminants to nearby populations.

The Management and Operating (M&O) contractor monitored soil, vegetation, and direct radiation on the INEEL to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The M&O contractor collected approximately 500 soil, vegetation, and direct radiation samples for analysis in 2003.

Argonne National Laboratory-West (ANL-W) and the Naval Reactors Facility (NRF) also conduct monitoring of soil, vegetation, and direct radiation. These programs are to show compliance with DOE orders but are limited in scope to their specific facilities.

The Environmental Surveillance, Education and Research (ESER) contractor conducted offsite environmental surveillance and collected samples from an area of approximately 23,308 km<sup>2</sup> (9000 mi<sup>2</sup>) of southeastern Idaho at locations on, around, and distant to the INEEL. The ESER contractor collected approximately 250 agricultural products, wildlife, and direct radiation samples for analysis in 2003.

Section 7.2 presents the agricultural products and wildlife surveillance results sampled under the ESER Program. Section 7.3 presents the results of soil sampling by both the ESER contractor and the M&O contractor. The direct radiation surveillance results are presented in Section 7.4. Results of the waste management surveillance activities are discussed in Section 7.5.

The INEEL Oversight Program collect split samples with the M&O and other INEEL contractors of the various agricultural products and soil, and maintain collocated direct radiation monitors. Results of the Oversight programs monitoring are presented in annual reports prepared by that organization and are not reported here.

The analytical results reported in the following surveillance sections are those that are greater than three times the analytical uncertainty (see Appendix B for information on statistical methods). Analytical uncertainties reported in text and tables are plus or minus one standard deviations ( $\pm 1s$ ) uncertainty for the radiological analysis.

Table 7-1. Other environmental monitoring activities at the INEEL.

Area/Facility <sup>a</sup>	Media				
	Agricultural Products	Wildlife	Soil	Vegetation	Direct Radiation
<b>Argonne National Laboratory-West</b>					
ANL-W			•	•	
<b>Management and Operating Contractor</b>					
CFA			•		
RWMC			•	•	•
PBF/CITR				•	•
Sitewide <sup>b</sup>			•	•	•
<b>Naval Reactors Facility</b>					
NRF			•	•	•
<b>Environmental Surveillance, Education and Research Program</b>					
INEEL/Regional	•	•	•	•	•
<b>INEEL Oversight Program</b>					
INEEL/Regional	• <sup>c</sup>		•		•
<p>a. ANL-W = Argonne National Laboratory-West, CFA = Central Facilities Area, RWMC = Radioactive Waste Management Complex, PBF/CITR = Power Burst Facility/Critical Infrastructure Test Range, and NRF = Naval Reactors Facility</p> <p>b. Sitewide includes thermoluminescent dosimeters located at major facilities (e.g., CFA, NRF, and ANL-W).</p> <p>c. The only agricultural product collected by the INEEL Oversight Program is milk.</p>					





## 7.2 Agricultural Products and Wildlife Sampling

### *Milk*

During 2003, 146 milk samples were collected under the ESER Program. All of the samples were analyzed for gamma-emitting radionuclides including iodine-131 ( $^{131}\text{I}$ ). During the first and third quarters, selected samples were analyzed for tritium. During the second and fourth quarters, selected samples were analyzed for strontium-90 ( $^{90}\text{Sr}$ ).

Strontium-90 was detected in seven out of nine samples ranging from  $0.7 \pm 0.2$  pCi/L at Howe to  $1.4 \pm 0.3$  pCi/L in a sample from Terreton. All levels of  $^{90}\text{Sr}$  in milk were consistent with those data previously reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by ingestion of grass by cows (EPA 1995). The maximum value is lower than the DOE Derived Concentration Guide for  $^{90}\text{Sr}$  in water of 1,000 pCi/L. No other radionuclides were detected above the  $\pm 3\text{s}$  uncertainty level.

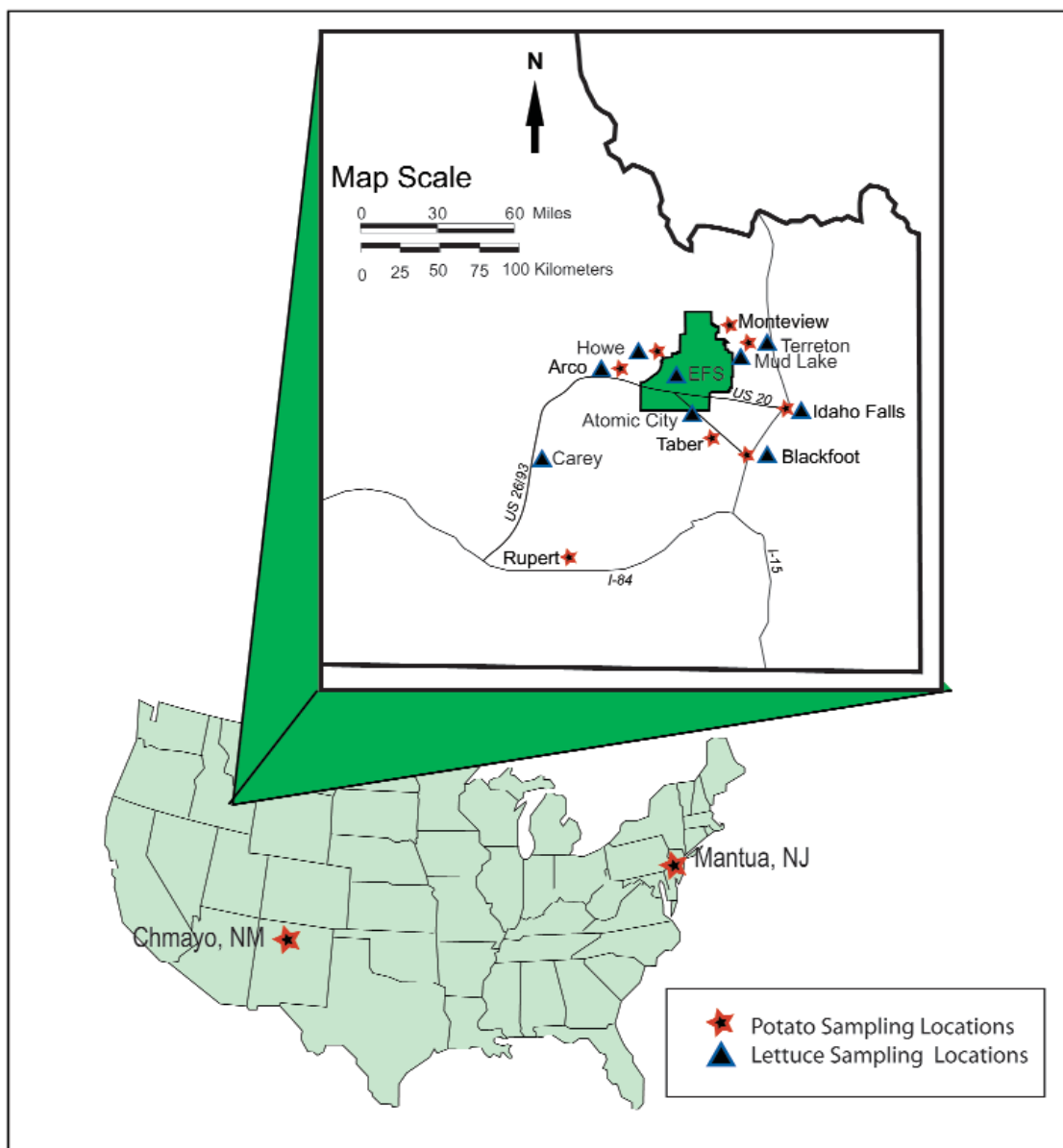
### *Lettuce*

The ESER program personnel collect lettuce samples every year from the areas adjacent to the INEEL. The collection of lettuce from home gardens around the INEEL is typically random. To make this sampling more deliberate, ESER added two prototype lettuce planters in conjunction with other sampling locations at Atomic City and the Experimental Field Station (EFS) on the INEEL. These locations were relatively remote and had no access to water, requiring that a self-watering system be developed. This method allows for the placement and collection of lettuce at areas previously unavailable to the public (i.e., on the INEEL). The boxes are set out in the spring with the lettuce grown from seed. This new method also allows for the accumulation of deposited radionuclides on the plant surface throughout the growth cycle. Figure 7-1 shows the nine locations where lettuce was collected in 2003.

Seven lettuce samples, including one duplicate, were collected from regional private gardens and two were collected from the portable lettuce gardens placed at Atomic City and EFS. Strontium-90 above the 3s uncertainty was detected in one of the lettuce samples from the EFS on the INEEL at a level of  $(0.4 \pm 0.1)$  pCi/g ( $[1.6 \pm 0.5] \times 10^{-2}$  Bq/g) (Table 7-2). Cesium-137 ( $^{137}\text{Cs}$ ) was detected in one sample at  $(1.1 \pm 0.3)$  pCi/g ( $[3.9 \pm 1.2] \times 10^{-2}$  Bq/g) at Idaho Falls. Strontium-90 and  $^{137}\text{Cs}$  in lettuce results from plant uptake of these isotopes in soil as well as deposition from airborne dust containing  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ . Strontium-90 and  $^{137}\text{Cs}$  are present in soil as a residual of fallout from aboveground nuclear weapons testing, which took place between 1945 and 1980. The quantities detected in 2003 are similar to those identified in past years. Therefore, these detections were most likely from weapons testing fallout.

### *Wheat*

None of the 13 wheat samples (including one duplicate and one blank) collected during 2003 contained a measurable concentration of  $^{90}\text{Sr}$  above the 3s uncertainty level. No other anthropogenic radionuclides were detected (Table 7-3) (DOE-ID 2003).



**Figure 7-1. Locations of lettuce and potato samples taken during 2003.**

## **Potatoes**

Eleven potato samples, including one duplicate, were collected during 2003: four samples and one duplicate from distant locations, four samples from boundary locations, and two samples from out-of-state locations (New Jersey and New Mexico) (Figure 7-1). The eight Idaho samples were collected from Arco, Blackfoot, Howe, Idaho Falls, Montevideo, Rupert, Terreton, and Taber. Strontium-90 was detected in four of the Idaho samples at an average level of  $(3.4 \pm 0.1) \times 10^{-1}$  pCi/g. The maximum detected concentration was  $(4 \pm 1) \times 10^{-1}$  pCi/g from a sample collected at Howe. Strontium-90 is present in soil as a result of fallout from aboveground nuclear weapons testing, and these detections were most likely from that fallout. No other anthropogenic radionuclides were detected in potatoes.

Table 7-2. Strontium-90 concentrations in garden lettuce (1998-2003).<sup>a,b</sup>

Location	1998	1999	2000	2001	2002 <sup>c</sup>	2003
<b>Distant Group</b>						
Blackfoot	NS <sup>d</sup>	NS	NS	NS	120 ± 240	228 ± 249
Carey	200 ± 75	120 ± 120	295 ± 210	144 ± 165	280 ± 240	220 ± 540
Idaho Falls	70 ± 60	60 ± 60	61 ± 75	114 ± 165	25 ± 75	254 ± 510
<b>Grand Mean<sup>e</sup></b>	<b>135 ± 48</b>	<b>90 ± 68</b>	<b>330 ± 111</b>	<b>201 ± 117</b>	<b>150 ± 116</b>	<b>234 ± 261</b>
<b>Boundary Group</b>						
Arco	200 ± 150	120 ± 60	81 ± 62	88 ± 165	93 ± 68	126 ± 480
Duplicate					36 ± 36	324 ± 360
Atomic City <sup>f</sup>	NS	NS	NS	NS	NS	282 ± 390
Howe	100 ± 135	60 ± 105	88 ± 72	21 ± 165	65 ± 84	25 ± 243
Split					78 ± 90	NS
Montevieu	100 ± 75	225 ± 300	NS	74 ± 165	85 ± 66	NS
Mud Lake (Terreton)	100 ± 120	160 ± 120	51 ± 77	40 ± 165	110 ± 78	214 ± 420
<b>Grand Mean<sup>e</sup></b>	<b>125 ± 62</b>	<b>140 ± 87</b>	<b>73 ± 41</b>	<b>56 ± 83</b>	<b>78 ± 30</b>	<b>200 ± 173</b>
<b>INEEL</b>						
Experimental Field <sup>f</sup> Station	NS	NS	NS	NS	NS	442 ± 390

a. Analytical results are times 10<sup>-3</sup> picocuries per gram (pCi/g).

b. Analytical results are for dry weight plus or minus three standard deviations (± 3s).

c. Approximate minimum detectable concentration (MDC) of <sup>90</sup>Sr in lettuce is 2 x 10<sup>-4</sup> pCi/g dry weight.

d. NS indicates no sample collected or sample was lost before analysis.

e. Uncertainty calculated as  $3 \left( \sqrt{\sum_{i=1}^n s_i^2} \right) / n$  where  $s_i$  is the standard deviation of sample  $i$  and  $n$  is the number of samples within the group.

f. Portable lettuce garden.

## Sheep

Certain areas of the INEEL are open to grazing under lease agreements managed by the U.S. Bureau of Land Management. Every year, during the second quarter, ESER personnel collect samples from sheep grazed in these areas, either just before or shortly after they leave the INEEL. Muscle, liver, and thyroid samples were collected from each animal. For the calendar year 2003, six sheep were sampled. Four were from INEEL land, and two were from Dubois to serve as control samples. Cesium-137 was detected above 3s in the muscle tissue of one onsite sample at a level of  $(12.1 \pm 1.5) \times 10^{-3}$  pCi/g but was not detected in offsite muscle samples. Cesium-137 was also detected in the liver tissue sample from the same onsite animal at a level of  $(4.9 \pm 1.5) \times 10^{-3}$  pCi/g. Cesium-137 was not measured above the 3s uncertainty in any control sheep in 2003. However, all <sup>137</sup>Cs concentrations measured in 2003 were similar to those found

Table 7-3. Strontium-90 concentrations in wheat (1998-2003).<sup>a,b</sup>

Location	1998	1999	2000	2001 <sup>c</sup>	2002	2003
Distant Group						
Aberdeen	NS <sup>d</sup>	NS	NS	NS	36 ± 390	84 ± 186
Blackfoot	8 ± 6	5 ± 8	6 ± 9	60 ± 149	69 ± 195	NS
Blackfoot <sup>e</sup>	NS	NS	NS	NS	81 ± 405	NS
Carey	NS	8 ± 5	NS	49 ± 270	28 ± 195	-53 ± 141
Idaho Falls	7 ± 5	8 ± 9	5 ± 5	-37 ± 132	50 ± 240	121 ± 192
Idaho Falls	NS	NS	NS	NS	240 ± 405	NS
Menan	NS	NS	NS	NS	NS	54 ± 165
Minidoka	6 ± 5	4 ± 5	6 ± 6	218 ± 435	0.78 ± 285	61 ± 144
Roberts (Menan)	NS	NS	NS	NS	19 ± 195	16 ± 153
Rockford	NS	NS	NS	NS	-220 ± 390	196 ± 204
Rupert	NS	NS	NS	NS	90 ± 405	48 ± 168
Duplicate	NS	NS	NS	NS	NS	-26 ± 156
Tabor	NS	NS	NS	NS	110 ± 450	NS
Grand Mean <sup>g</sup>	6 ± 3	6 ± 3	6 ± 5	73 ± 138	46 ± 102	42 ± 503
Boundary Group						
Arco	6 ± 5	5 ± 5	6 ± 6	95 ± 390	41 ± 570	2 ± 162
Duplicate				59 ± 131	120 ± 540	NS
Howe	NS	NS	NS	NS	18 ± 225	-19 ± 147
Montevieu	9 ± 6	6 ± 8	2 ± 3	50 ± 146	220 ± 300	NS
Mud Lake	8 ± 6	3 ± 5	5 ± 6	19 ± 111	54 ± 255	8 ± 168
Terreton	7 ± 5	5 ± 6	3 ± 5	63 ± 195	86 ± 300	5 ± 162
Grand Mean <sup>g</sup>	8 ± 3	5 ± 3	4 ± 3	57 ± 98	90 ± 159	-1 ± 480

<sup>a</sup>. Concentrations are 10<sup>-3</sup> picocuries per gram.  
<sup>b</sup>. Analytical Results are for dry weight, plus or minus 3 standard deviations (± 3s).  
<sup>c</sup>. Approximate MDC of <sup>90</sup>Sr in wheat through 2000 was 4 x 10<sup>-3</sup> pCi/g dry weight. After 2001, the MDC increased to 20 x 10<sup>-3</sup> pCi/g dry weight.  
<sup>d</sup>. NS = no sample collected.  
<sup>e</sup>. Samples were collected from two Blackfoot locations in 2002.  
<sup>f</sup>. Uncertainty calculated as  $3 \left( \sqrt{\sum_{i=1}^n s_i^2} \right) / n$ , where s is the standard deviation of sample i and n is the number of samples in the group.





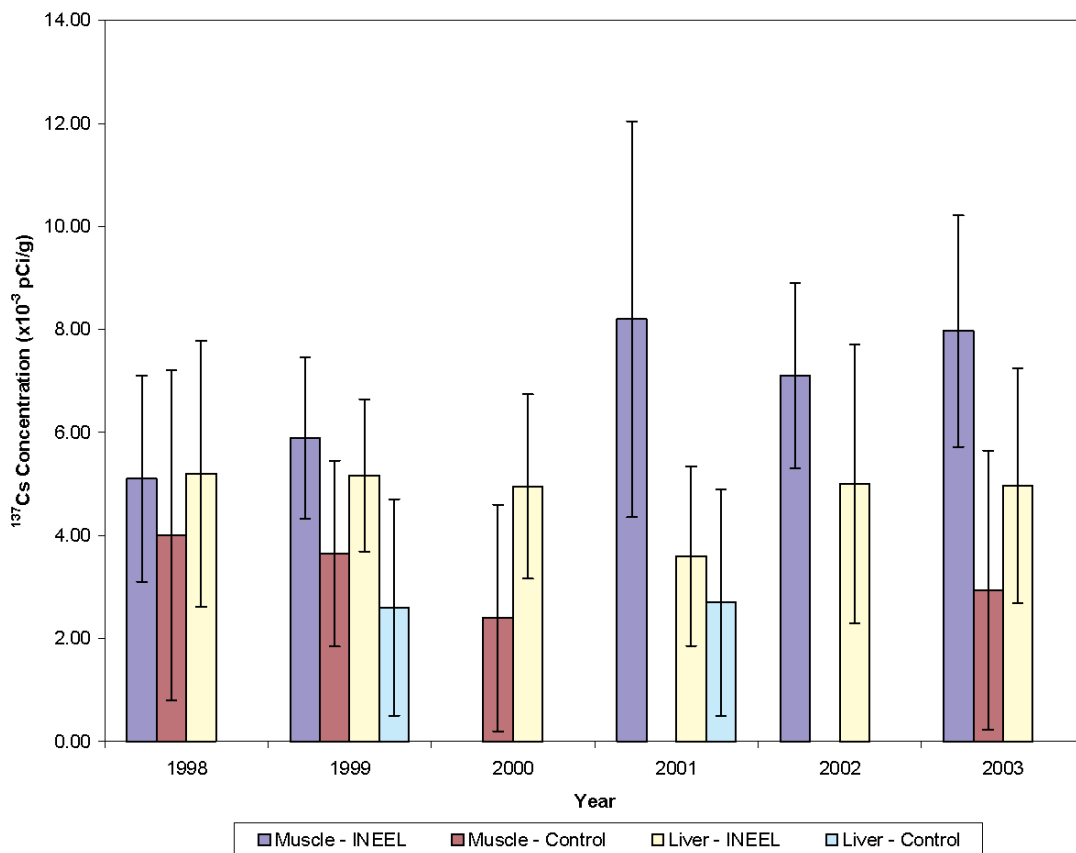
in both onsite and offsite sheep samples in previous years and are within historical values. Cesium-137 concentrations in both sheep liver and muscle have been essentially the same (error bars overlap) since 1998 (DOE-ID 2003) (Figure 7-2). Iodine-131 did not exceed the 3s uncertainty in any sample.

### Game Animals

Muscle, liver, and thyroid samples were collected from nine mule deer, nine pronghorn, and two elk, which were accidentally killed on INEEL roads. There was detectable  $^{137}\text{Cs}$  radioactivity above 3s in the muscle and thyroid from two different mule deer, and in the liver of two and muscle of three pronghorn taken on or near the INEEL. Additionally, one muscle sample and one liver sample from pronghorn contained detectable  $^{131}\text{I}$  above 3s (Table 7-4).

In 1998 and 1999, four pronghorn, five elk, and eight mule deer muscle samples were collected as background samples from hunters across the Western United States: three from central Idaho; three from Wyoming; three from Montana; four from Utah; and one each from New Mexico, Colorado, Nevada, and Oregon. Each background sample had small, but detectable,  $^{137}\text{Cs}$  concentrations in its muscle ranging from  $(5.1 \pm 1.5) \times 10^{-3}$  to  $(15 \pm 0.2) \times 10^{-3}$  pCi/g.

Muscle results from animals sampled in 2003 were within this range, from  $(4.7 \pm 1.2) \times 10^{-3}$  to  $(15 \pm 2) \times 10^{-3}$  pCi/g. The 2003 values were also within the range of historical values. The



**Figure 7-2. Cesium-137 concentrations in muscle and liver of sheep collected from the INEEL and control areas.**

**Table 7-4. Detectable concentrations of  $^{131}\text{I}$  and  $^{137}\text{Cs}$  in game tissue on and near the INEEL in 2003.<sup>a</sup>**

Tissue	Number of Samples	Minimum	Maximum	Mean
<b>Mule Deer (<math>^{137}\text{Cs}</math>)</b>				
<b>Muscle</b>	1		$5.1 \pm 4.4 \text{ E-3}$	
<b>Thyroid</b>	1		$5.0 \pm 4.4 \text{ E-3}$	
<b>Pronghorn (<math>^{137}\text{Cs}</math>)</b>				
<b>Muscle</b>	3	$4.7 \pm 4.1 \text{ E-3}$	$1.5 \pm 0.6 \text{ E-2}$	$9.1 \pm 4.9 \text{ E-3}$
<b>Liver</b>	2	$8.1 \pm 4.3 \text{ E-3}$	$1.1 \pm 0.6 \text{ E-2}$	$9.0 \pm 1.3 \text{ E-3}$
<b>Pronghorn (<math>^{131}\text{I}</math>)</b>				
<b>Muscle</b>	1		$1.1 \pm 0.6 \text{ E-2}$	
<b>Liver</b>	1		$8.4 \pm 5.7 \text{ E-3}$	
<b>a Concentrations in picocuries per gram <math>\pm</math> 3 standard deviations.</b>				

highest value for  $^{137}\text{Cs}$  was recorded in the muscle of a pronghorn at  $(15 \pm 2) \times 10^{-3} \text{ pCi/g}$  collected on the INEEL between Central Facilities Area (CFA) and Idaho Nuclear Technology and Engineering Center (INTEC). The same pronghorn also had  $^{131}\text{I}$  in the muscle at  $(11 \pm 2) \times 10^{-3} \text{ pCi/g}$  and liver at  $(8.4 \pm 1.9) \times 10^{-3} \text{ pCi/g}$ . These values can be attributed to the ingestion of radionuclides in plants from worldwide fallout associated with aboveground nuclear weapons testing. No  $^{131}\text{I}$  was detected in any of the thyroid gland samples.

Marmots are hunted and consumed by the Shoshone-Bannock Tribes. During 1998, 2000, 2002, and 2003, a total of 15 marmots were collected from the Radioactive Waste Management Center (RWMC) and 11 from control areas (Table 7-5). During 1998 and 2000, marmots were collected at random locations near the RWMC. During 2002 and 2003, marmots were collected at known contaminated areas at RWMC (primarily near the SDA and Pit 9), which biased the results toward higher concentrations. Muscle, viscera, and fur/bone samples were collected from each, sent to a commercial radiochemistry laboratory, and analyzed for Americium-241 ( $^{241}\text{Am}$ ), Plutonium-238 ( $^{238}\text{Pu}$ ), Plutonium-239/240 ( $^{239/240}\text{Pu}$ ),  $^{90}\text{Sr}$ , and gamma-emitting radionuclides.

Analyses indicated that analytes were generally below detectable levels in all tissues from control animals (Table 7-5). One animal collected from RWMC contained low levels of  $^{137}\text{Cs}$  in all three tissue types. The  $^{137}\text{Cs}$  concentrations detected in 2002 and 2003 were approximately one order of magnitude higher than those detected in marmots collected around the RWMC in 1998 (DOE-ID 2003). However, the  $^{137}\text{Cs}$  concentrations observed in the 2002/2003 animals were below those observed in other wildlife species collected previously at the SDA as well as in control animals collected for an older study (Arthur and Janke 1986).

Strontium-90 levels followed a similar pattern to  $^{137}\text{Cs}$  (both are also worldwide fallout products) in external tissues (Table 7-5). However, muscle tissue collected in 2002 and 2003 showed a decrease from the 1998 concentrations. The animals sampled in 2002 and 2003 were





Table 7-5. Maximum radionuclide concentrations in edible, fur/bone or viscera tissues from marmots collected at RWMC and control areas in 1998, 2000, and 2003.<sup>a</sup>

Edible Tissues									
Radionuclide	1998 RWMC (6) <sup>b</sup>	1998 Control (3)	2000 RWMC (3)	2000 Control (3)	2002 RWMC (3)	2002 Control (2)	2003 RWMC (3)	2003 Control (3)	2003 Control (3)
<sup>90</sup> Sr	0.122±0.096	0.157±0.011	BD	BD	0.018±0.017	0.004±0.005	0.071±0.019	BD	BD
<sup>134</sup> Cs	0.015±0.021	BD	BD	BD	BD	BD	BD	BD	BD
<sup>137</sup> Cs	0.016±0.018	0.018±0.015	BD	BD	0.274±0.051	BD	0.405±0.049	BD	BD
<sup>238</sup> Pu	0.001±0.002	BD	BD	BD	BD	BD	BD	BD	BD
<sup>239/240</sup> Pu	BD <sup>c</sup>	BD	BD	BD	BD	BD	BD	BD	BD
<sup>241</sup> Am	BD	BD	BD	BD	BD	BD	0.0013±0.0012	BD	BD
<sup>60</sup> Co	0.013±0.012	BD	BD	BD	BD	BD	BD	BD	BD
<sup>141</sup> Ce	16.1±16.1	BD	BD	BD	BD	BD	BD	BD	BD
<sup>95</sup> Nb	1.395±1.383	BD	BD	BD	BD	BD	BD	BD	BD
External Tissues (Fur/Bone/Viscera)									
Radionuclide	1998 RWMC (0) <sup>b</sup>	1998 Control (0)	2000 RWMC (3)	2000 Control (3)	2002 RWMC (3)	2002 Control (2)	2003 RWMC (3)	2003 Control (3)	2003 Control (3)
<sup>90</sup> Sr	NA <sup>d</sup>	NA	90±84	BD	2.64±0.81	BD	4.74±1.47	0.197±0.068	BD
<sup>134</sup> Cs	NA	NA	BD	BD	BD	BD	BD	BD	BD
<sup>137</sup> Cs	NA	NA	0.012±0.011	BD	0.177±0.035	BD	0.002±0.002	BD	BD
<sup>238</sup> Pu	NA	NA	BD	BD	BD	BD	BD	BD	BD
<sup>239/240</sup> Pu	NA	NA	BD	BD	BD	BD	0.0010±0.001	BD	BD
<sup>241</sup> Am	NA	NA	BD	BD	0.004±0.005	BD	0.0028±0.002	BD	BD
<sup>60</sup> Co	NA	NA	BD	BD	BD	0.0006±0.001	BD	BD	BD
<sup>141</sup> Ce	NA	NA	BD	BD	BD	0.005±0.006	BD	BD	BD
<sup>95</sup> Nb	NA	NA	BD	BD	BD	0.04±0.045	BD	BD	BD

<sup>a</sup> Units are in pCi/g ± 3 standard deviations.

<sup>b</sup> (n) = Total number of samples taken.

<sup>c</sup> BD = Below Detection limits.

<sup>d</sup> NA = Not Analyzed

collected from the Pit 9 area. Again, these concentrations were well below  $^{90}\text{Sr}$  levels detected in animals in previous studies at the subsurface disposal area (SDA) (Arthur and Janke 1986).

Eleven waterfowl were collected during 2003: three control samples from Mud Lake, five from the Test Reactor Area (TRA) Northeast Cold Pond, and three from ANL-W waste ponds. Samples of the exterior, edible portions, and the remainder (33 samples total plus three duplicates) of all these waterfowl were analyzed for gamma-emitting radionuclides with a subset analyzed for  $^{90}\text{Sr}$ ,  $^{241}\text{Am}$ ,  $^{238}\text{Pu}$ , and  $^{239/240}\text{Pu}$ . All 11 ducks had positive detections for one or more radionuclides in at least one tissue type. Total radionuclide concentrations for those samples are summarized in Table 7-6. The potential dose from consuming these ducks is discussed in Chapter 8.

Mourning doves were not collected in 2003.

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### 7.3 Soil Sampling

Soils are sampled to determine if long-term deposition of airborne materials released from the INEEL have resulted in a buildup of radionuclides in the environment and to support the Wastewater Land Application Permit for the CFA Sewage Treatment Plant. Samples are analyzed for gamma-emitting radionuclides,  $^{90}\text{Sr}$ , and certain actinides. Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world. Of these,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ ,  $^{238}\text{Pu}$ ,  $^{239/240}\text{Pu}$ , and  $^{241}\text{Am}$ , all of which potentially could be released from INEEL operations, are of particular interest because of their abundance from nuclear fission events (e.g.,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ ) or from their persistence in the environment because of long half-lives (e.g.,  $^{239/240}\text{Pu}$  with a half-life of 24,390 years).

The ESER contractor collects offsite soil samples every two years (in even years); thus no soil sampling was conducted in 2003. Results from 1976 to 2002 are presented in Figure 7-3 for a perspective. Radionuclide levels in soils at 186 site surveillance locations near major INEEL facilities were measured by the M&O contractor in 2003 using in situ gamma spectrometry with additional grab samples from 0 to 5 cm (0 to 2 in.) at selected locations. Table 7-7 summarizes the in situ gamma results.

#### *Wastewater Land Application Permit Soil Sampling at CFA*

The Wastewater Land Application Permit (WLAP) for the CFA Sewage Treatment Plant allows for nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation (DOE-ID 1999, IDEQ 2000). Soils are sampled from the CFA land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.) and 30 to 61 cm (12 to 24 in.) at each location and composited, yielding two composite samples, one from each depth. These samples are analyzed for pH, electrical conductivity, sodium absorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the WLAP, to determine whether wastewater application is resulting in detrimental changes in soil quality. These results are presented in Table 7-8. Preapplication data collected by Cascade Earth Sciences, Ltd. in 1993 are presented for comparison purposes in Table 7-8.





Table 7-6. Radionuclide concentrations in eight waterfowl using INEEL wastewater (sewage) disposal ponds and three waterfowl from background locations (2003).<sup>a</sup>

Nuclide	Waterfowl Species and Location											
	Coot		Coot		Coot		Edible		Mallard		Green-winged Teal	
	TRA	TRA	TRA	TRA	TRA	TRA	ANL-W	American Widgeon	Northern Shoveler	ANL-W	Mud Lake	Mud Lake
<sup>141</sup> Ce	-- <sup>b</sup>	176±165	--	--	--	--	--	79.3±108.0	139±165	--	--	--
<sup>137</sup> Cs	--	--	--	--	--	--	--	--	30.0±34.5	--	--	--
<sup>60</sup> Co	--	--	--	--	--	--	--	--	35.4±37.5	--	34.9±40.5	--
<sup>95</sup> Nb	--	--	--	--	--	--	--	--	--	--	187±210	--
<sup>241</sup> Am	--	--	--	--	--	--	--	2.0±3.5	--	--	--	--
<sup>239/240</sup> Pu	--	--	--	--	--	--	--	--	1.8±3.2	--	--	--
<sup>90</sup> Sr	16.9±22.5	--	18.7±16.5	--	--	18.0±12.3	--	--	--	--	10.6±9.0	9.9±13.4
Exterior (Feathers and Gut)												
<sup>241</sup> Am	14.5±18.0	--	--	--	--	7.9±13.8	--	--	--	12.9±18.0	--	--
<sup>141</sup> Ce	--	--	--	--	--	--	--	--	--	--	52.6±72.0	--
<sup>134</sup> Cs	--	--	--	--	--	--	--	--	--	--	--	66.4±53.0
<sup>137</sup> Cs	--	--	--	--	--	--	--	--	6.9±10.2	--	--	36.5±46.5
<sup>60</sup> Co	--	--	8.2±11.7	--	--	--	--	--	--	--	--	31.0±42.0
<sup>152</sup> Eu	--	--	--	18.4±21.0	--	--	--	--	--	--	--	--
<sup>124</sup> Sb	34.7±42.0	--	--	--	--	--	--	--	--	--	--	--
<sup>239/240</sup> Pu	--	--	--	--	--	--	--	--	6.0±10.4	--	--	--
<sup>90</sup> Sr	252±195	227±131	201±210	269±195	--	--	282±180	258±315	201±195	--	144±180	438±357
Remainder (Bones, Remaining Organs, Residual Muscle)												
<sup>241</sup> Am	--	2.3±3.2	--	--	--	3.6±4.5	--	--	--	--	1.7±2.7	--
<sup>134</sup> Cs	17.2±25.5	--	--	21.7±28.5	--	--	25.2±27.0	23.3±33.0	14.8±19.5	--	--	32.9±36.0
<sup>137</sup> Cs	--	--	--	19.4±25.5	--	--	--	--	--	--	--	--
<sup>58</sup> Co	--	--	--	--	--	--	--	44.9±57.0	--	--	--	--
<sup>51</sup> Cr	--	--	--	--	--	--	1070±1350	--	--	--	--	--
<sup>54</sup> Mn	--	--	--	--	--	--	--	--	--	--	--	36.0±48.0
<sup>239/240</sup> Pu	--	--	--	--	--	--	--	--	--	--	0.96±1.65	--
<sup>90</sup> Sr	49.5±22.5	71.5±24.0	78.2±37.5	149±40.5	63.0±22.5	56.6±22.5	213±62	--	--	--	116±33	63.3±24.0
												79.3±22.5

a. All values are  $\times 10^{-3}$  picocuries per gram  $\pm$  3 standard deviations

b. A double dash (--) indicates the radionuclide was not detected in the sample.

c. Results in shaded columns are background (control) samples.

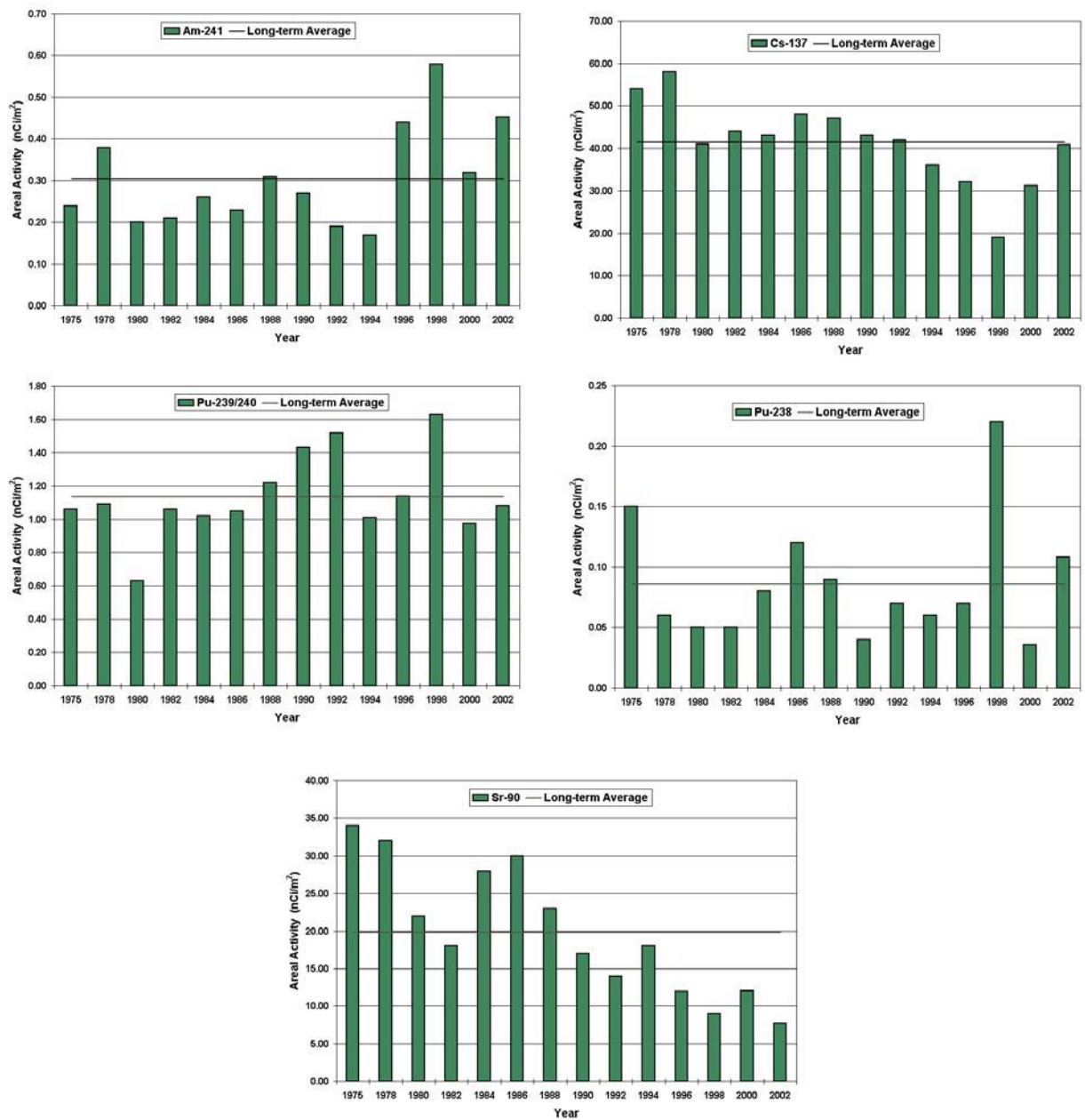


Figure 7-3. Geometric mean areal activity in offsite surface (0 to 5 cm [0 to 2 in.]) soils (1975 to 2002; soils were not collected in 2003).



**Table 7-7. In situ gamma results measured by the M&O contractor (2003).**

Location	Radionuclide	Concentration <sup>a</sup>			Comment
		Minimum	Maximum	Mean	
ARA	Cesium-137	0.2 ± 0.1	152.8 ± 0.1	10.2	Concentrations above background for the INEEL, but consistent with historical concentrations at ARA.
ANL-W	Cesium-137	0.53 ± 0.10	1.20 ± 0.05	0.72	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
INTEC	Cesium-137	1.1 ± 0.1	23.0 ± 0.1	5.2	Concentrations above background for the INEEL, but consistent with historical concentrations at INTEC.
Large Grid	Cesium-137	0.34 ± 0.03	0.80 ± 0.14	0.62	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.
NRF	Cesium-137	0.27 ± 0.05	1.10 ± 0.06	0.57	Concentrations within background for the INEEL and surrounding areas and attributable to past fallout.

a. Concentrations are in picocuries per gram ±2s.

Soil pH has remained fairly constant during the application period (Table 7-8). Percent organic matter has varied around preapplication concentrations; however, it is expected to take several years for decomposed vegetation to be incorporated into the soil profile.

The soil salinity averages are within acceptable ranges based on electrical conductivity results. Soil salinity levels between 0 to 2 mmhos/cm are generally accepted to have negligible effects on plant growth (Bohn et al. 1985). During 2003, the electrical conductivity in both the 0 to 30 cm (0 to 12 in.) and the 30 to 61 cm (12 to 24 in.) intervals increased slightly over historical levels but remained well below the recommended 2 mmhos/cm maximum. Soils with sodium adsorption ratios below 15 are generally classified as not having sodium or salinity problems (Bohn et al. 1985). While 2003 sodium adsorption ratios were elevated at both depths relative to preapplication levels and to historical average levels, they remain well below the ratio generally indicating a sodium problem in soil.

Nitrogen data suggest negligible nitrogen accumulation from wastewater application. The low soil-available nitrogen (ammonium-nitrogen and nitrate-nitrogen) concentrations suggest that the native sagebrush and grass vegetation use all of the plant-available nitrogen and that the total nitrogen application is low. Increased nutrients and water from wastewater application may be stimulating plant growth, which in turn rapidly utilizes plant available nitrogen. The ammonium and nitrate nitrogen concentrations are comparable to those of unfertilized, background agricultural soils.

**Table 7-8. CFA Sewage Treatment Plant land application area soil monitoring results (2003).**

Parameter <sup>a</sup>	Preapplication Data <sup>b</sup>		Application Period 1995 through 2002				2003
	Depth (in.)	1993	Depth (in.)	Historical Minimum (1995–2002)	Historical Maximum (1995–2002)	Historical Average (1995–2002)	
pH (standard units)	0–6	7.6	0–12	7.6	8.4	8.1	7.97
	6–16	8.0	12–24	7.6 <sup>c</sup>	8.6 <sup>c</sup>	8.2 <sup>c</sup>	8.02
	16–30	8.1	—	—	—	—	—
Electrical Conductivity (mmhos/cm)	0–6	0.6	0–12	0.36	1.20	0.77	1.22
	6–16	0.7	12–24	0.20	1.64	0.70	1.27
	16–30	0.6	—	—	—	—	—
Organic Matter (%)	0–6	2.2	0–12	0.44 <sup>c</sup>	3.09 <sup>c</sup>	1.65 <sup>c</sup>	1.15
	6–16	1.6	12–24	0.56	2.29	1.12	0.62
	16–30	1.4	—	—	—	—	—
Nitrate-Nitrogen	0–6	16	0–12	0.68 <sup>d</sup>	6.00	3.10 <sup>e</sup>	4.03
	6–16	6	12–24	0.43 <sup>d</sup>	5.20	2.10 <sup>e</sup>	1.06
	16–30	3	—	—	—	—	—
Ammonium-Nitrogen	0–6	7.9	0–12	0.81 <sup>f</sup>	6.10	3.11 <sup>e</sup>	2.04 <sup>g</sup>
	6–16	7.6	12–24	0.84 <sup>f</sup>	6.00	2.76 <sup>e</sup>	2.00 <sup>g</sup>
	16–30	7.4	—	—	—	—	—
Phosphorus <sup>h</sup>	0–6	29	0–12	3.69	12.0	7.79 <sup>e</sup>	8.85
	6–16	18	12–24	2 U	10.2	3.79 <sup>e</sup>	2.05 <sup>g</sup>
	16–30	12	—	—	—	—	—
Sodium Adsorption Ratio	0–6	1.0	0–12	0.35	6.72	2.72	6.20
	6–16	1.4	12–24	0.31	4.03	1.59	9.12
	16–30	2.6	—	—	—	—	—

a. All values are in milligrams per kilogram unless otherwise noted.

b. Preapplication sample results were based on a composite of three representative samples taken at each depth. Preapplication soil depths and locations differ from permit samples.

c. The minimum, maximum, and average shown do not reflect a result from 1995. While samples were collected in 1995, the analytical laboratory failed to analyze them.

d. Only includes values that were greater than the detection limit.

e. Where applicable, half the reported detection limit was used to calculate the average.

f. U = the reported result is below the detection limit.

g. Reported as below detection limit. Half detection limit is shown.

h. Available phosphorus was analyzed rather than total phosphorus.



In 2003, available phosphorus concentrations remained below preapplication concentrations and less than that considered adequate for range and pasture crop growth (EPA 1981).

Based on these results, the application of wastewater at the CFA does not appear to adversely affect soil chemistry. However, sampling and analysis will continue, as required by the WLAP, to evaluate potential long-term effects.

### *Argonne National Laboratory-West*

Argonne National Laboratory-West (ANL-W) collects four soil samples annually, two from the predominant wind direction and two from the crosswind directions. Sufficient material to fill a 500 mL (16 oz) wide mouth jar is collected from 0 to 5 cm (0 to 2 in.) depth within an approximately 1 m<sup>2</sup> (approximately 10 ft<sup>2</sup>) area. Samples are analyzed for low-level gamma-emitting radionuclides, and uranium, plutonium, and thorium isotopes. Table 7-9 presents the results of the 2003 sampling effort.

**Table 7-9. Soil radiochemistry results reported by ANL-W (2003).**

Radionuclide	Concentrations <sup>a</sup>			Location of Maximum Result
	Minimum	Maximum	Average	
Human-Made				
<sup>137</sup> Cs	0.221	9.79	1.560	IW Pond <sup>b</sup>
<sup>238</sup> Pu	0	0.014	0.004	Air Monitor #1
<sup>239/240</sup> Pu	0.004	0.025	0.013	Air Monitor #1
Naturally Occurring				
<sup>228</sup> Ac	0.951	1.32	1.170	Air Monitor #1
<sup>7</sup> Be	-0.08	0.302	0.072	Air Monitor #4
<sup>214</sup> Bi	0.843	1.21	1.005	Air Monitor #4
<sup>214</sup> Pb	1.03	1.23	1.15	Air Monitor #1
<sup>40</sup> K	17.7	23.3	19.95	Air Monitor #1
<sup>226</sup> Ra	0.843	1.21	1.005	Air Monitor #4
<sup>228</sup> Th	1.18	1.37	1.238	Air Monitor #1
<sup>230</sup> Th	1.15	1.51	1.236	Air Monitor #1
<sup>232</sup> Th	1.05	1.42	1.216	Air Monitor #1
<sup>233/234</sup> U	0.618	1.81	0.943	IW Pond
<sup>235/236</sup> U	0.079	0.134	0.104	Air Monitor #1
<sup>238</sup> U	0.613	1.32	0.860	IW Pond

a. All concentrations are in picocuries per gram (pCi/g).

b. IW Pond refers to the ANL-W Industrial Waste Pond.

## Naval Reactors Facility

Naval Reactors Facility personnel also sample soil and vegetation annually for programmatic radionuclides. For detailed information see the 2003 Environmental Monitoring Report for the Naval Reactors Facility (Bechtel Bettis 2003).

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### 7.4 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures to ambient ionizing radiation. The TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. The TLDs are sensitive to beta energies greater than 200 kilo-electron volts (keV) and to gamma energies greater than 10 keV. The TLD packets contain four lithium fluoride chips and are placed about 1 m (approximately 3 ft) above the ground at specified locations. The four chips provide replicate measurements at each location. The TLD packets are replaced in May and November of each year. The sampling periods for 2003 were from November 2002 through April 2003 (spring) and from May 2003 through October 2003 (fall).

The measured cumulative environmental radiation exposure for offsite locations from November 2002 through October 2003 is shown in Table 7-10 for two adjacent sets of dosimeters maintained by the ESER and M&O contractors. For purposes of comparison, annual exposures from 1999-2002 are also included for each location.

The mean annual exposures from distant locations in 2003 were  $114 \pm 2$  milliroentgens (mR) as measured by ESER contractor dosimeters and  $117 \pm 3$  mR, as measured by the M&O contractor dosimeters (Table 7-10). For boundary locations, the mean annual exposures were  $113 \pm 2$  mR as measured by ESER contractor dosimeters and  $115 \pm 3$  mR as measured by M&O contractor dosimeters. Using both ESER and M&O data, the average dose equivalent of the distant group was 119 millirem (mrem), when a dose equivalent conversion factor of 1.03 was used to convert from milliroentgens to millirem in tissue (NRC 1997). The average dose equivalent for the boundary group was 117 mrem.

In addition to TLDs, the M&O contractor uses a global positioning radiometric scanner system to conduct gamma radiation surveys. The global positioning radiometric scanner is mounted on a four-wheel drive vehicle. The two plastic scintillation detectors of the radiometric scanner measure gross gamma in counts per second with no coincidence corrections or energy compensation. Elevated count rates suggest possible areas of contamination or elevated background areas. Both global positioning system and radiometric data are continuously recorded. The vehicle is driven at approximately 8 km/hr (5 mph) to collect survey data (see Section 7.5, Waste Management Surveillance Sampling).

Onsite TLDs maintained by the M&O contractor representing the same exposure period as the offsite dosimeters are shown in Appendix D, Figures D-1 through D-10. The results are expressed in  $\text{mR} \pm 1$  standard deviation. Onsite dosimeters were placed on facility perimeters, concentrated





Table 7-10. Annual environmental radiation exposures (1999-2003).<sup>a</sup>

Distant Group	1999			2000			2001			2002			2003		
	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER	M&O	ESER
Distant Group															
Aberdeen	130 ± 5	124 ± 4	144 ± 14	133 ± 9	152 ± 11	137 ± 10	141 ± 10	126 ± 9	123 ± 4	122 ± 9					
Blackfoot	111 ± 2	111 ± 3	138 ± 14	126 ± 9	145 ± 10	136 ± 9	125 ± 9	119 ± 9	117 ± 4	111 ± 8					
Blackfoot (CMS) <sup>b</sup>	113 ± 7		114 ± 11		134 ± 7		113 ± 8		101 ± 4						
Blue Dome <sup>c</sup>							106 ± 8		103 ± 4						
Craters of the Moon	115 ± 6	120 ± 7	126 ± 13	121 ± 9	137 ± 10	136 ± 9	121 ± 9	124 ± 9	116 ± 4	122 ± 9					
Dubois <sup>c</sup>							109 ± 8		98 ± 3						
Idaho Falls	124 ± 7	108 ± 5	129 ± 13	123 ± 9	147 ± 10	127 ± 9	126 ± 9	112 ± 8	126 ± 9	111 ± 8					
Jackson <sup>c</sup>							97 ± 7		97 ± 7						
Minidoka	112 ± 4	113 ± 6	118 ± 12	111 ± 8	131 ± 9	122 ± 9	111 ± 8	107 ± 8	111 ± 8	104 ± 7					
Rexburg	129 ± 3	110 ± 6	148 ± 15	120 ± 8	155 ± 11	131 ± 9	144 ± 10	115 ± 8	136 ± 5	116 ± 8					
Roberts	131 ± 5	129 ± 5	137 ± 14	139 ± 10	157 ± 11	144 ± 11	134 ± 13	132 ± 9	126 ± 4	133 ± 9					
Mean	121 ± 2	116 ± 2	132 ± 5	125 ± 4	146 ± 4	133 ± 4	120 ± 3	119 ± 3	114 ± 2	117 ± 3					
Boundary Group															
Arco	128 ± 6	124 ± 4	128 ± 13	121 ± 9	143 ± 10	134 ± 9	126 ± 9	120 ± 9	113 ± 4	118 ± 8					
Atomic City	124 ± 4	133 ± 3	131 ± 13	128 ± 9	147 ± 10	137 ± 9	130 ± 9	124 ± 9	120 ± 4	124 ± 9					
Howe	118 ± 1	116 ± 5	118 ± 12	114 ± 9	133 ± 9	130 ± 9	121 ± 9	NS <sup>d</sup>	109 ± 4	110 ± 8					
Montevieu	114 ± 1	108 ± 7	122 ± 12	116 ± 9	134 ± 10	120 ± 8	118 ± 8	115 ± 8	106 ± 4	112 ± 8					
Mud Lake	129 ± 5	128 ± 7	140 ± 14	126 ± 9	151 ± 11	140 ± 10	136 ± 10	129 ± 9	124 ± 4	122 ± 8					
Birch Creek Hydro	113 ± 5	113 ± 9	118 ± 12	108 ± 8	114 ± 8	107 ± 8	110 ± 8	104 ± 7	105 ± 4	105 ± 7					
Mean	121 ± 2	120 ± 3	126 ± 5	119 ± 4	137 ± 4	128 ± 4	124 ± 4	118 ± 4	113 ± 2	115 ± 3					

a. All values are in milliroentgens with ± 1 standard deviation.

b. The M&O contractor does not sample at the Blackfoot Community Monitoring Station (CMS).

c. These stations were added by the ESER contractor in 2002.

in areas likely to show the highest gamma radiation readings. Other onsite dosimeters are located in the vicinity of radioactive materials storage areas. At some facilities, elevated exposures result from areas of soil contamination around the perimeter of these facilities.

The maximum exposure onsite recorded during 2003 was  $348 \pm 25$  mR at location TRA 2. This location is near a radioactive materials storage area, which is inside the facility fence line. Locations TRA 2, 3, and 4 are also adjacent to the former radioactive disposal ponds, which have been drained and covered with clean soil and large rocks. The levels at TRA 2 and 3 have been reduced by approximately 50 percent from 2002 (DOE-ID 2003).

The INTEC 20 TLD is located near a radioactive material storage area with an exposure of  $249 \pm 17$  mR. The maximum exposure occurred at the INTEC tree farm at  $221 \pm 15$  mR near Tree Farm 4. Exposures at INTEC 20, INTEC Tree Farm 1, and INTEC Tree Farm 4 for 2003 were all comparable to historical exposures.

Table 7-11 summarizes the calculated effective dose equivalent an individual receives on the Snake River Plain from various background radiation sources.

The terrestrial portion of natural background radiation exposure is based on concentrations of naturally occurring radionuclides found in soil samples collected in 1976 (the last time a comprehensive background study was completed). Concentrations of naturally occurring radionuclides in soil are not expected to change significantly over this relatively short time period. Data indicated the average concentrations of uranium-238 ( $^{238}\text{U}$ ), thorium-232 ( $^{232}\text{Th}$ ), and potassium-40 ( $^{40}\text{K}$ ) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from  $^{238}\text{U}$  plus decay products,  $^{232}\text{Th}$  plus decay

**Table 7-11. Calculated effective dose equivalent from background sources (2003).**

Source of Radiation Dose Equivalent	Total Average Annual Dose <sup>a</sup>	
	Calculated	Measured
<b>External</b>		
Terrestrial	75	NA <sup>b</sup>
Cosmic	48	NA
Subtotal	123	117
<b>Internal</b>		
Cosmogenic	1	
Inhaled Radionuclides	200	
$^{40}\text{K}$ and others	39	
Subtotal	240	
<b>Total</b>	<b>363</b>	
a. All values are in millirem.		
b. NA indicates terrestrial and cosmic radiation parameters were not measured individually.		





products, and  $^{40}\text{K}$  based on the above average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr. Because snow cover can reduce the effective dose equivalent Idaho residents receive from the soil, a correction factor must be made each year to the above estimate of 76 mrem/yr. For 2003, this resulted in a corrected dose of 75 mrem/yr because of snow cover, which ranged from 2.54 to 12.7 cm (1 to 5 in.) in depth with an average of 5.95 cm (2.34 in.) over 32 days with recorded snow cover (Table 7-11).

The cosmic component varies primarily with altitude increasing from about 26 mrem at sea level to about 48 mrem at the elevation of the INEEL at approximately 1500 m (4900 ft) (NCRP 1987). Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2003 was 123 mrem (Table 7-11). This is above the 119 mrem measured at distant locations by ESER and M&O TLDs after conversion from milliroentgens to millirem in tissue. These values are very close and within normal variability (Table 7-10). Therefore, it is unlikely that INEEL operations contribute to background radiation levels at distant locations.

The component of background dose that varies the most is inhaled radionuclides. According to the National Council on Radiation Protection and Measurements, the major contributor of external dose equivalent received by a member of the public from  $^{238}\text{U}$  plus decay products are short-lived decay products of radon (NCRP 1987). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of the soil and rock of the area. This also varies between buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 200 mrem was used in Table 7-11 for this component of the total background dose because no specific estimate for southeastern Idaho has been made, and few specific measurements have been made of radon in homes in this area. Therefore, the effective dose equivalent from natural background radiation for residents in the INEEL vicinity may actually be higher or lower than the total estimated background dose of about 363 mrem shown in Table 7-11 and will vary from one location to another.

### ***Naval Reactors Facility***

The NRF also has TLDs placed around the perimeter fence of the facility and at distant locations to measure cumulative exposure. For detailed information see the *2003 Environmental Monitoring Report for the Naval Reactors Facility* (Bechtel Bettis 2003).

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## **7.5 Waste Management Surveillance Sampling**

Vegetation, soil, and direct radiation sampling are performed at RWMC and Waste Experimental Reduction Facility (WERF) in compliance with DOE Order 435.1, "Radioactive Waste Management" (DOE 2001).

### ***Vegetation Sampling***

At the RWMC, vegetation is collected from the four major areas shown in Figure 7-4. Crested wheat grass and perennials are collected in odd-numbered years. Samples of crested wheat grass

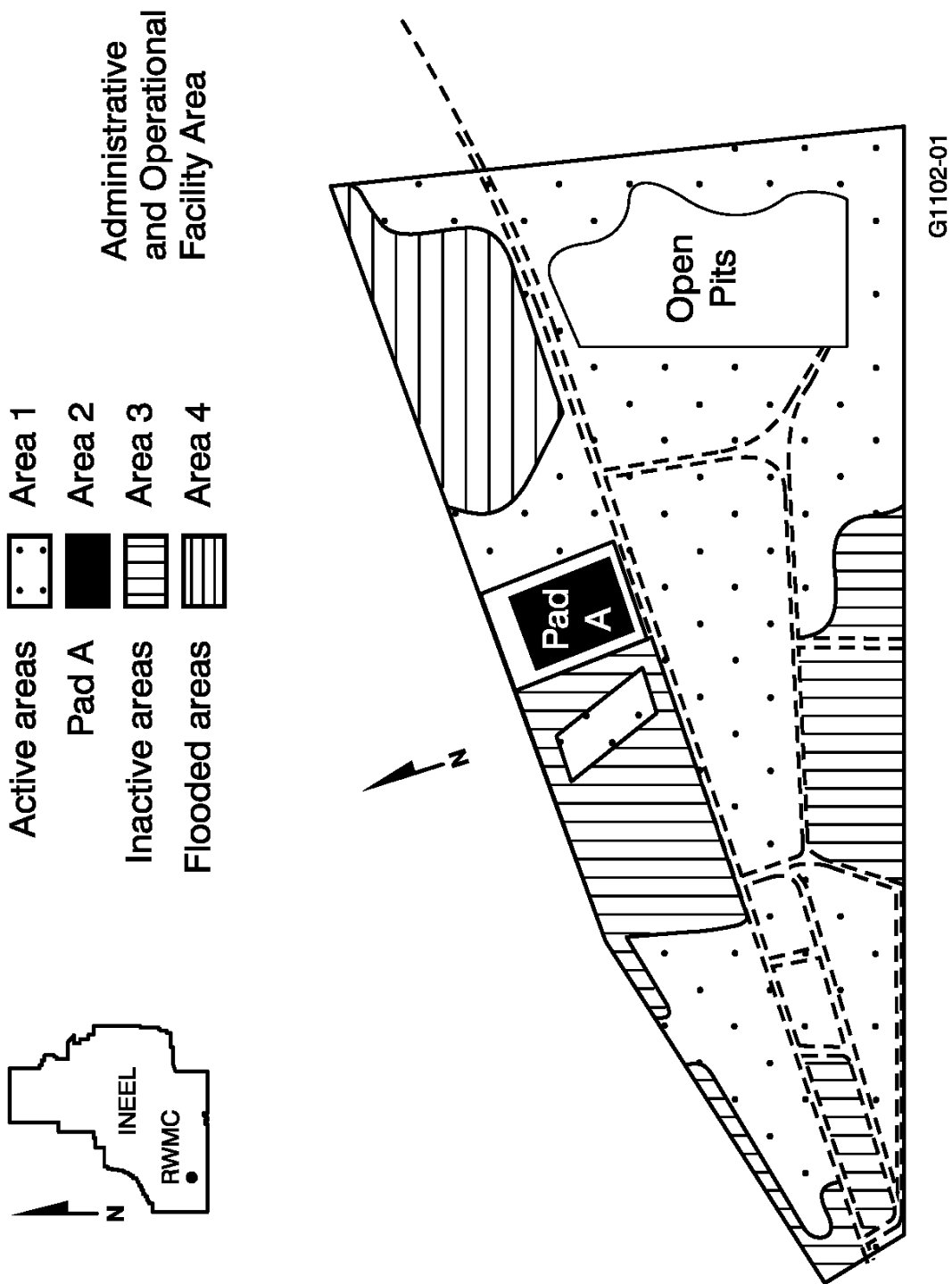


Figure 7-4. Four major areas of the RWMC used for M&O waste management vegetation collection.





Table 7-12. Vegetation radiochemistry results reported by ANL-W (2003).<sup>a</sup>

Radionuclide	Concentrations <sup>a</sup>			Location of Maximum Result
	Minimum	Maximum	Average	
Human-Made				
Cesium-137	-0.107	0.181	0.053	Air Monitor #3
Plutonium-238	-0.001	0.009	0.001	IW Ditch
Plutonium-239/240	-0.0003	0.009	0.003	IW Ditch
Naturally Occurring				
Actinium-228	0.057	1.01	0.321	Air Monitor #1
Beryllium-7	0	9.44	3.864	Air Monitor #4
Bismuth-214	0.028	0.814	0.229	IW Pond
Lead-214	-0.146	0.7	0.194	IW Pond
Potassium-40	10.5	78.8	24.913	IW Pond
Radium-226	0	0.228	0.127	Air Monitor #4
Thorium-228	0.010	0.909	0.146	IW Ditch
Thorium-230	0.0199	0.699	0.121	IW Ditch
Thorium-232	0	0.811	0.139	IW Ditch
Uranium-233/234	0.012	0.767	0.134	IW Ditch
Uranium-235/236	0.001	0.123	0.020	IW Ditch
Uranium-238	0.009	0.642	0.091	IW Ditch

a. Concentrations are in picocuries per gram.





## Soil Sampling

Biennial soil sampling was conducted during 2003. Soil samples were collected at the RWMC locations shown in Figure 7-6, at 0-5 cm (0-2 in.). The soils were analyzed for gamma-emitting radionuclides. The maximum  $^{137}\text{C}$  sample concentration was  $(1.3 \pm 0.03)$  pCi/g (20 percent of Environmental Concentration Guide [EG&G 1986]). Selected samples were analyzed for specific alpha-emitting and beta-emitting radionuclides. Table 7-13 summarizes the results of human-made radionuclides. Cesium-137,  $^{239/240}\text{Pu}$ , and  $^{90}\text{Sr}$  concentrations are within background for the INEEL and surrounding areas and are attributable to past fallout. Americium-241 concentrations are above background for the INEEL but are consistent with historical concentrations at RWMC and are attributable to past operational activities and fallout.

## Direct Radiation

The radiometric scanner system was used to conduct soil surface radiation (gross gamma) surveys at the SDA to complement soil sampling. The global positioning radiometric scanner is mounted on a four-wheel drive vehicle. The system includes two plastic scintillators that measure gross gamma in counts per second with no coincidence corrections or energy compensation (elevated count rates indicate possible areas of contamination or elevated background). Both the global positioning system and radiometric data are continuously recorded.

Figure 7-7 shows the radiation readings from the 2003 RWMC annual fall survey. The survey around the active low-level waste pit was comparable to, or lower than, historical measurements for that area. No new elevated readings were identified during the survey. The maximum activity was 359 micro R/hr and identified at the west end of Trench 58. Although readings varied slightly from year to year, the results are comparable to previous years' measurements taken at the same locations.

Pad A cannot be surveyed via the global positioning radiometric scanner because of driving restrictions. Therefore, it was traversed with a hand-held detector. No elevated readings were identified on Pad A during the annual fall survey.

**Table 7-13. RWMC soil sampling results (2003).**

Parameter	Minimum Concentration <sup>a</sup>	Maximum Concentration <sup>a</sup>	%ECG <sup>b</sup>
Cesium-137	$0.029 \pm 0.008$	$1.26 \pm 0.04$	21.0
Americium-241	$0.007 \pm 0.0002$	$0.193 \pm 0.013$	0.48
Plutonium-239/240	$0.007 \pm 0.002$	$0.077 \pm 0.006$	0.10
Strontium-90	$0.010 \pm 0.005$	$0.179 \pm 0.027$	2.98

a. Concentrations are in picocuries per gram  $\pm$  1 standard deviation.  
b. ECG = Environmental Concentration Guide (EG&G 1986) in picocuries per gram.

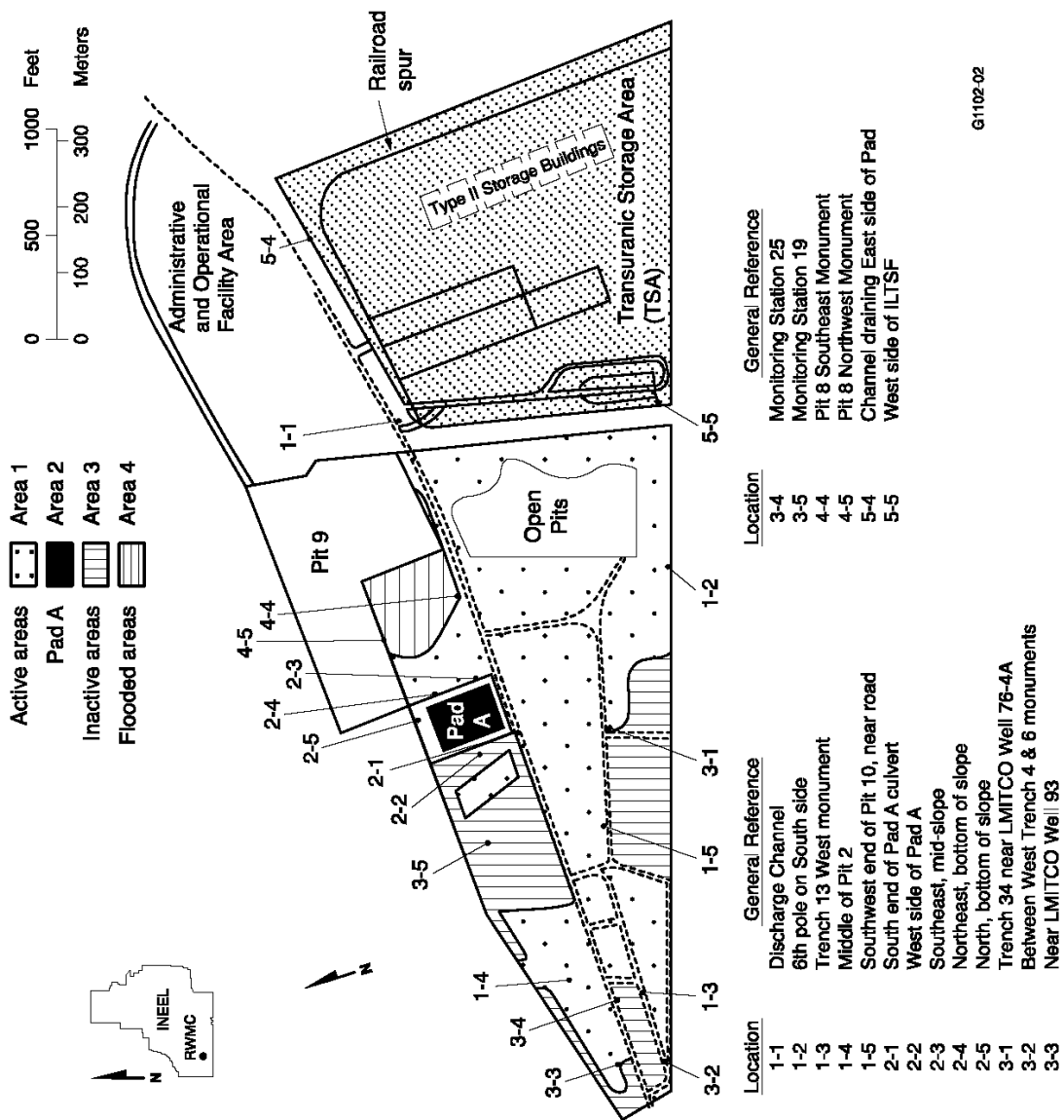
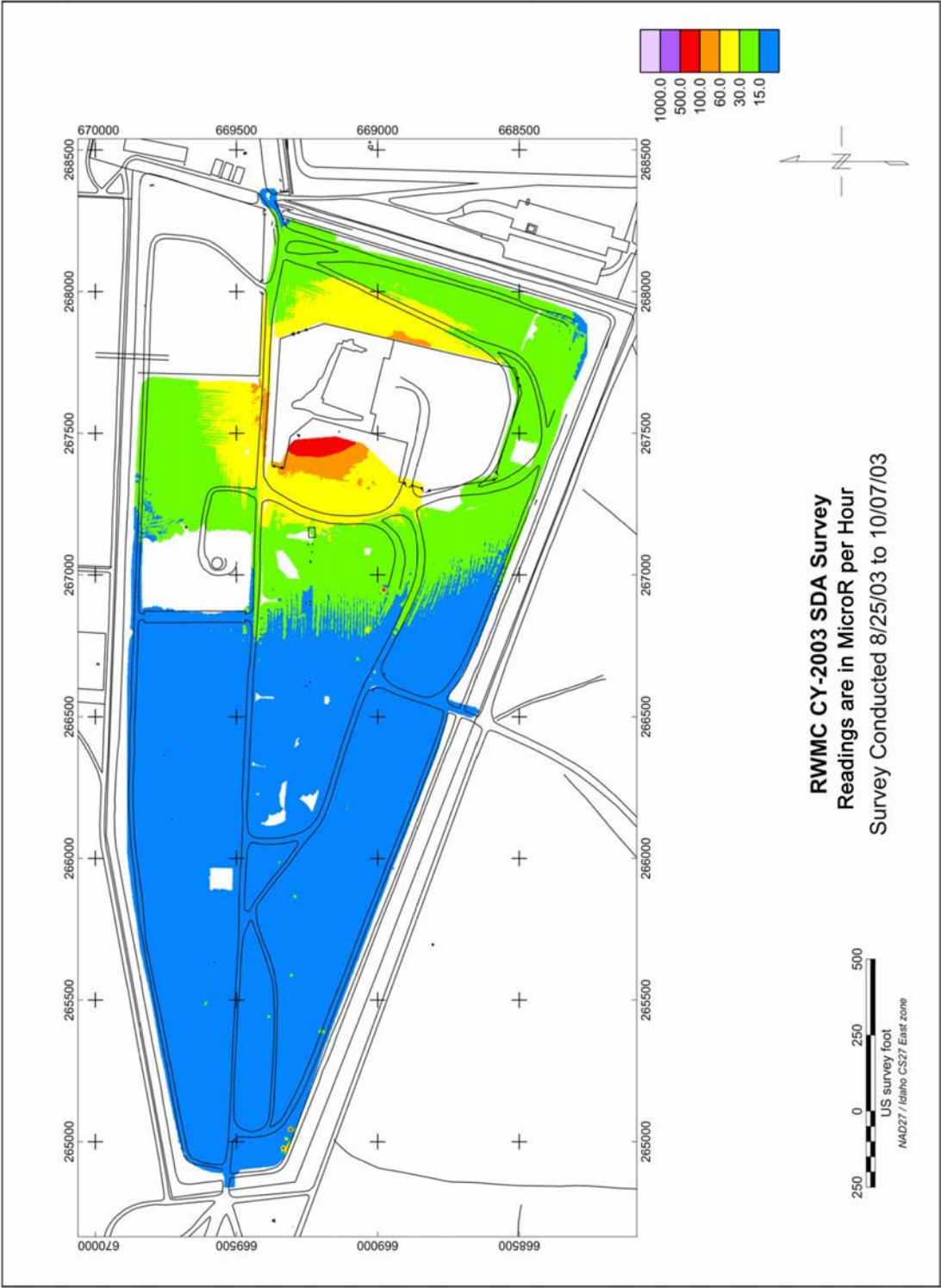


Figure 7-6. RWMC soil sampling locations.





Figure 7-7. RWMC surface radiation survey fall 2003.



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